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DOCTRINE OF SPECIFIC NERVE ENERGIES

THE doctrine of specific nerve energies was first definitely formulated by Johannes Müller (1801–1858). Physiologists before his time had regarded the sense nerves as merely conductors, each of which, however, had a special sensibility to some peculiar impression, and hence was the mediator of some definite quality of *external* bodies. Müller pointed out that the discovery of the possibility of arousing different sensations in different nerves by the same stimulus, *e. g.*, electricity, and also of the fact that different stimuli, *e. g.*, electrical and mechanical, can produce in the same sense organ similar sensations, had rendered the theory of the susceptibility of nerves to certain impressions inadequate and unsatisfactory. He therefore advanced the theory that "each peculiar nerve has a special power or quality, which the exciting cause merely renders manifest"; and that in sensations we do not experience the qualities or states of external bodies, but merely the conditions of the nerves themselves. Hence light, sound, and other apparently external qualities, as such, have no existence, but are states which certain unknown external influences excite in our nerves.

It is clear that Müller considered the sensory nerves themselves as the seat of the "specific energy"; and thought that the function of the central organ consisted in the connection of the nerves into a system, the reflection of the sensations upon the origin of the motor nerves, ideation, remembrance, and attention. His theory, also, seems to refer to modality only and not to quality; that is, a single specific nervous energy is provided for each sense organ; and, therefore, any sensory apparatus may respond to different forms of adequate stimuli in a variety of ways.

Helmholtz first distinguished between modality and quality. Sensations differ in quality when it is possible to pass by a series of intervening sensations from one to the other. They differ in modality when this can not be done, *e. g.*, visual and auditory sensations. Helmholtz attempted to explain *quality*, also, by postulating

a specific energy for each nerve *fiber,* that is, he sought for specific energies within the individual sense organs; and his theories of visual and auditory processes depend upon this further application of the doctrine, *e. g.,* each of the colors, red, green, and violet, depends upon a specific process. Helmholtz must have interpreted the law somewhat differently from his predecessors, for he regarded these specific differences in *quality* as determined by the character of the *external* physical stimulus. In apparent contradiction to this he held that *modality* was exclusively subjective. But if quality depends upon external stimuli, the same must be said of modality, for the latter is a mere concept or general term. There is no such thing as tasting in *general* or seeing in general. What we taste or see is always a *particular* quality.

Before proceeding we must refer to a certain ambiguity in the term "specific energy." It confuses *function* with property or quality. It makes, of course, a great deal of difference whether *specific property* or *specific function* is meant by the phrase. Most writers on the subject have used the term so loosely that it is difficult to know just what they mean when they speak of "specific energy." Wundt would scarcely deny the specific energy, in the sense of specific *function,* of any given nervous unit; but he would deny it in the sense of a specific property, that is, specific chemical or physical process, in that unit as a correlate of a specific quality of sensation. Of course the latter meaning includes the former, but the opposite is not true—at least not necessarily so. Müller meant by the doctrine a specific nervous process, and so, we think, did Helmholtz.

McDougall leaves no doubt as to his position when he says: "The nervous *process* which is the immediate exciting cause of each quality of sensation is different from that which excites any other quality of sensation"; and that "it is a difference which could, if we knew more about it, be expressed in physical or chemical terms." He advances the following proofs for his theory: (1) Whenever it has been found possible to stimulate a nerve or sense organ by inadequate stimuli, the resulting sensation is of a similar quality to that produced by stimulation of the same nerve or sense organ by its adequate stimulus, that is, the one that normally excites it. (2) The Helmholtz theories of visual and auditory processes, which offer the most satisfactory explanation of the facts (?), depend upon this doctrine. (3) Unlike effects must have unlike causes, therefore unlike sensations must depend upon unlike nervous processes.

McDougall differs from Müller in placing the seat of the specific energy not in the nerves themselves, but in the cerebral cortex, and especially in the synaptic processes. His reasons for so doing are as

follows: (1) If the specific quality were in the nerves or sense organs, we would have to consider these processes as directly affecting consciousness. This is improbable since loss of a sense organ or nerve does not prevent the recurrence of the same quality of sensation in imagination, while loss of the cortical structure does. (2) The conduction processes of all sensory nerves appear similar in kind. (3) It is in harmony with the principle of strict localization of cerebral functions and the principle of association; for if the cortex were of indifferent function, it would be difficult to understand why the excitement of an associated group might not on one occasion be accompanied by one sensation, and on others by entirely different sensations or psychical states. (4) This specialized character belongs to the synapse, because the nerve cells are anatomically similar and have as their function to preside over nutrition; also the synaptic processes are highly fatiguable and transmit the nervous impulse discontinuously. These features seem likewise characteristic of psychical phenomena.

It is noteworthy that as our knowledge of the processes concerned has advanced, the seat of the specific quality has receded from the nerves to the cell-bodies and thence to the synapse. That is, with the progress of physiology and anatomy, the advocates of the theory have been forced to withdraw this *qualitas occulta* from known to unknown regions. It seems likely, as Wundt remarks, that in the future the specific energy will be placed in the sense organs themselves, where differences of structure and function warrant the assumption.

Wundt holds that the different qualities of sensations depend *not* on the specific *character* of nervous elements, but solely upon the different modes of their connection. The principle of connection of elements asserts that the "simplest psychical content has a complex physiological substrate," *e. g.,* the sensation of red has a complex connection of nervous elements as its physical correlate. It is not, however, so much the connection of nerve elements with one another, as their connection with organs and tissue elements and through these with external stimuli, that determines the specific quality of sensation. A specific physical or chemical process as the basis for each primary quality of sensation is an *unnecessary* hypothesis which involves many difficulties and is wholly unprovable. True, certain connections or systems of elements have specific functions, which, however, have been acquired under pressure of the external conditions of life.

This leads to the hypothesis of the original indifference of function, which is founded upon the following observations: (1) A fairly long continuance of any function is necessary before the correspond-

ing sense qualities appear in imagination, *e. g.*, if a person becomes blind in *early life*, he has no visual imagery. (2) Functional disturbances occasioned by lesions are sometimes removed by a *vicarious* functioning of other elements. Here the specific function arises during the lifetime of an individual. Of course we *inherit dispositions*, which consist in the connection of nervous and tissue elements, etc.; but, even so, the development of their specific functions demands the actual discharge of these functions upon excitation of the end organs by external stimuli.

The indifference of elementary function (and certainly property) is also proved anatomically by the essential identity of structure; physiologically, by the essential *identity* of nervous processes; and psychologically, by the fact that elementary qualities of sensation are referred to functions of peripheral elements.

The doctrine of specific nerve energies is contrary to the physiological doctrine of the development of the senses and hence to the whole theory of evolution. According to the latter our various senses arose through differentiation from a common sensibility—a differentiation due to the action of external stimuli upon the organism, and the adaptation of the latter to a complex environment. Hence each sense organ is excited only by those stimuli to which it has become specially adapted, and is unaffected by others. Even the sense organs, then, are only secondary in determining the qualities of sensations. These must ultimately be referred to external stimuli. The specific character of the sensation most probably consists in the *attitude* which we assume towards the external stimulus—an attitude determined by the *connection of nervous* and other elements.

We remarked above that each sense organ or nerve was excited only by its adequate stimuli, but it is just because there are exceptions to this rule that the doctrine of specific energies was first formulated. Electrical stimulation will produce sensations of light, taste, or smell, etc. Mechanical stimuli will produce visual or auditory sensations; direct electrical stimulation or section of the nervus opticus will "cause flashes of light"; and it is said that mechanical, chemical, or thermal excitation of the chorda tympani will produce sensations of taste. These are the chief facts that can be brought to bear in favor of the theory, and which any other theory must endeavor to explain; but even if otherwise inexplicable, they can not be regarded as proofs of the doctrine, but merely as illustrations.

According to Wundt, all these cases of abnormal stimulation can be explained by the principle of "practise and adaptation." The impressions which the sense organs are adapted to receive, by virtue of inherited or developed *connections of elements*, arouse certain sensations; and when this mode of responding has become habitual,

the accustomed excitation is set up by inadequate stimuli. Külpe says that sensory nerve fibers with centrifugal conduction have been demonstrated in the case of the nervus opticus, and that the visual sensations aroused by electrical stimulation of this nerve are due to the fact that the nervous excitation is first conveyed to the retina by these efferent sensory fibers, and thence pursues its normal or accustomed path of discharge. These centrifugal fibers may exist in all sensory nerves; but even if they do not, the alternative theory that stimulation arouses the accustomed excitation in the visual system of elements is not difficult; and far simpler than the theory of a *qualitas occulta* different for every primary quality of sensation.

If the doctrine of specific energies were true, we see no reason why there would not be a much more far-reaching *indifference of the stimuli* than is actually the case. The inadequate stimuli are limited in number, and there are many *negative instances* against the theory: *e. g.,* mechanical stimuli will not produce sensations of taste or of smell; sound waves will not affect the nervus opticus, nor light waves the auditory nerve; temperature stimuli will not arouse other sensations, etc.

When electricity arouses the sensations of taste and smell, it may only prove that it is an *adequate* stimulus for these sensations, that is, that electricity can be tasted and smelt. There is at least nothing extraordinary in regarding electricity as an adequate stimulus for sight. Electrical and light waves are not essentially different; and, especially if one adopts Meisling's vibratory theory of vision, this conclusion appears highly plausible.

Then again an inadequate stimulus may contain within itself or give rise to the usual normal stimulus: *e. g.,* when a sensation of sound is produced by mechanical pressure, this may be due to sound waves produced in the inner ear by external pressure upon the organ of hearing; and when electrical stimulation produces a taste sensation, this may be due to a decomposition of the saliva, which frees the adequate stimulus.

A final objection against the indifference of the stimuli—or rather against the effects of inadequate stimuli as supposed by the doctrine of specific nerve energies—is a psychological one which seems to us of considerable importance. It seems introspectively untrue that adequate and inadequate stimuli produce sensations that are at all or essentially the same in character. There is always a quality or feeling associated with sensations produced by the latter, by which they can clearly be distinguished from sensations produced by the former. We are never deceived in this respect; and it certainly rests with the advocates of the doctrine to explain why this is so. If the theory were true, it would be difficult to understand why inade-

quate stimuli, *e. g.*, for sight, would not give us all the visual qualities of *objects,* even to externality and figure, which *light waves* are capable of giving us.

We saw above that McDougall advances in favor of the doctrine of specific energies the Helmholtz theories of visual and auditory processes, which he says offer the best explanation of the facts. We do not intend to enter into a discussion of the relative merits of the various theories of color sensations. Space will not permit. But we consider the Hering theory, which allows at least *two processes* for each structural element, far superior to that of Helmholtz. It affords a *better* explanation for the phenomena of color blindness, peripheral and faint light vision, the psychical primariness of blue and yellow, etc. Moreover, it has been demonstrated that the same cone can give rise to any or all of the sensations, red, green, and violet. This fact seems favorable to Meisling's vibratory theory, as well as incompatible with the doctrine of a specific process.

As Wundt very well remarks, "Many senses have no distinct sensory elements corresponding to different sensational qualities"—at least these have not been pointed out. This is especially true of smell, but holds to a lesser or greater extent of taste, vision, and even hearing, unless one adopts the Helmholtz theory of auditory processes. This theory may be seriously questioned; but even if true, it can scarcely afford an argument in favor of specific energies; because it may be replied that "the different qualities of the sensations are due not to any original specific *attribute* of nerve fibers or other sensory elements, but to the way in which single nerve fibers are *connected* with end organs," etc. The processes in these fibers and their connections, which may, perhaps, be called *specific functions,* depend upon external impressions, and this dependence is localized at the *periphery.*

When advocates of the doctrine of specific energies analyze sensations to obtain elementary qualities and ascribe to each of these a specific quality of nerve process, they overlook the fact that we have no definite criterion of the primariness of a sensation. The gray obtained by mixing colors has psychically no similarity whatever to the colors, *e. g.*, red and green, of which it is composed. How do we know that red may not itself consist of two or more equally dissimilar sensations? In fact Wundt's principle of the connection of elements would lead us to believe this; and physiologically it appears true. Our criterion of the primariness of red must then be a physical one —the simplicity of the etheric oscillations corresponding to this sensation. Here again we see external stimuli and not nerve process as the ultimate determining factor. This physical simplicity may cause (in fact *does* cause) excitation in a physiologically complex

system. Hence it does not militate against the principle of connection of elements.

Myers points out that "our tonal sensations are the result of a fusion between various primordial elements of which we must always remain ignorant." This is true if we accept the Helmholtz theory; for according to it, pitch depends upon the position of the most intensely stimulated fiber, and we *never* experience the result of stimulating a *single basilar fiber.* This is another illustration of the principle of connection of elements, and the dependence of quality of sensation upon peripheral as well as other elements.

Münsterberg's "action theory" can, we think, be used as an argument against specific nerve energies. At least it harmonizes very well with the view we have adopted and with Wundt's principle of connection of elements. According to this theory, sensory processes are attended by consciousness only when they discharge into actions. In other words, sensation depends upon motor reactions to external stimuli or objects. This seems to be the logical conclusion of Wundt's principle; for this reaction or motor attitude is determined by an inherited or developed *connection of elements.* The specific quality of sensations, then, is nothing more than the specific attitude we assume as determined by the motor discharge or rather by the whole sensory-motor arc. The chemical or physical process is, thus, the same in all nervous substance. There is no inexplicable difference here. This seems more intelligible, less fraught with difficulties, and more in accord with facts than the doctrine of specific energies in Müller's and McDougall's sense. We say in McDougall's sense because this theory does not deny "specific energies," if by the term is meant the *specific function* of a given sensory motor arc or connection, which function may, however, be changed or modified by incorporation into a larger system or by vicarious functioning, as mentioned above.

The action theory, it may be said, ascribes the *quality* of sensations to the *sensory path* and its ending; but, we answer, vividness, intensity, facilitation, etc., depend on the motor discharge, and without these there would be no quality, for these are *attributes* of the quality, and in any case the action theory may not, of course, be infallible in all respects.

A difficult question may be raised, viz.: Why is it that on loss of a sense organ, we still retain the corresponding imagery, while a cortical lesion in a specific area annihilates it? We sometimes forget that there is an important difference between a memory-image and a sensation. McDougall says, "An image resembles the sensation of which it is the representation or reproduction in every respect save that it lacks the vividness of the sensation." The image seems to

lack the tangibleness or feeling of *present* existence that accompanies the sensation. This, then, must be the quality contributed by the sense organ; for every element in the sensory-motor connection contributes its quota. Of course we must remember that without the sense organ there could be no sensations or images; and without external stimuli there would *have been no sense* organs. After a certain sensory-motor arc has been responding for a considerable time with a definite motor attitude to certain external stimuli, if the peripheral portion, the retina, *e. g.*, be then removed, the remaining part of the arc will continue by virtue of adaptation to respond in the *accustomed* manner, when excited by overflows from other arcs or systems with which it has been previously connected. The sensory-motor connections are intact. There is nothing to prevent discharge into *action*. The result is imagery (in this case visual) which, as before said, lacks certain important qualities of sensations, either because it involves but part of the arc or because the impulse can never be so great as that initiated by external stimuli, without which the motor reaction and hence the imagery would have been impossible; for the reaction that underlies the imagery is due to adaptations arising from the *habitual* assumption of the attitude. The doctrine of specific nerve energies, as we mentioned above, renders an explanation of imagery difficult if not impossible. McDougall's two theories seem to us inconsistent. He finds it difficult to explain how the seats of the physiological processes can be identical or partially identical and the resulting psychical phenomena different; and we find him hinting at the action theory, when he says, "Their motor tendencies are the same, the cortical excitement in both cases issues from the cortex by the same efferent paths."

Now, if instead of a sensory organ being removed, there is a lesion in a definite cortical area, *e. g.*, occipital lobe, how is it that imagery is lost? The answer to this follows from what we have said. In the former case the sensory-motor *connections* were intact; now they are severed. The motor discharge is, therefore, impossible. Hence, there can be no reaction or motor attitude and no imagery or sensations. New connections are sometimes formed and the lost sense thus regained. This is called by Wundt "the principle of vicarious function," and is itself a strong argument against specific energy.

In spite of McDougall's assertions to the contrary, we consider association inexplicable on the hypothesis of specific energy. The connection of absolutely unlike processes forever remains an enigma, while association by similarity of motor attitude or reaction seems quite intelligible; and his principle of "*strict* localization of cerebral functions," which of course *logically follows* from the "doctrine of

specific energies,'' is held by very few physiologists of the present day and still remains to be proved.

In conclusion the results of an interesting experiment performed upon cats by Langley and Anderson may be cited against the doctrine of specific energies. The cervical sympathetic nerve *contracts* the blood vessels of the submaxillary gland; the chorda tympani dilates these vessels. The cervical sympathetic was joined at its peripheral end to the chorda tympani. After union and regeneration, stimulation of the cervical sympathetic caused *dilation* of the vessels. This proves that a vaso-constrictor fiber can become a vaso-dilator fiber; and that whether contraction or dilation of the blood vessels occurs depends upon the mode of nerve ending. The experiment, of course, was performed upon efferent fibers, but it is not therefore without weight in a consideration of this problem; and it is of especial value in refuting the theory that the seat of the specific energy is in the nerve fibers.

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IS INVERSION A VALID INFERENCE?

TO the old immediate inferences recent writers add inversion. The inverse of All S is P is Some S is not P. Of No S is P the inverse is Some $\bar{S}$ is P. I and O have no inverse.

Inversion violates the fundamental principle of logic and common sense that we should not go beyond the evidence. Every conclusion, in order to be valid, must be rigidly limited to the content of the premises. Its content must not be greater than that of the premises, and it must not be of a different kind. Now $\bar{S}$, the contradictory of S, is an infinite term greater than S, for it includes all the universe[1] other than S. True, it is limited by the word *Some* in the conclusion, but that fails to make the reasoning good, because $\bar{S}$ is different in kind from S. An ordinary illicit process of the minor term is indeed cured by writing *Some* in the conclusion, as in the following example: No birds are viviparous; all birds are bipeds; therefore no bipeds are viviparous. The minor term is illicit, but the fault is easily cured by writing, Some bipeds are not viviparous. But the inverse also begins with *Some*. Why, then, is it still at fault? Simply because $\bar{S}$ is different in kind. Bipeds are the same two-legged creatures in the conclusion as in the minor premise; but every possible $\bar{S}$ differs from any possible S. Let S stand for ruminants; then $\bar{S}$ will represent non-ruminants. As lambs differ from

[1] Universe here means universe of discourse.

hyenas and oxen from tigers, so every possible ruminant differs from any conceivable non-ruminant. Inverting, All ruminants are herbivorous, we have, Some non-ruminants are not herbivorous. In the premise we are talking about cows; in the conclusion about lions. Can we infer anything about the food of lions, or any other non-ruminant, from the fact that cows eat grass?

Of the two fundamental requirements, (*a*) the content of the conclusion must not be greater than that of the premises, (*b*) it must not differ in kind, inversion clearly violates the second. Whether it does not also violate the first is a matter of doubt. The non-ruminants are much the larger group, and whether those of them which are not herbivorous exceed the ruminants or not, is a question for the naturalist. No matter how it turns out, the doubt is damning. Valid reasoning is free from any shadow of doubt.

Serious as this shadow of doubt may be, the other point, the difference in kind between the subject-matter of the conclusion and the premise, is far more damaging to inversion. Shifting ground severs the bond of inference. To infer the food of non-ruminants from that of ruminants would be a famous short-cut in zoology. Such an easy royal road would be a boon to the plodding naturalist patiently studying each group for itself.

Inversion makes no pretense of limiting its conclusion to the content of its premises. It boldly introduces new matter and is reckless in regard to quantity. It clearly goes beyond the evidence. The most common violation of that limiting principle of reason and common sense is illicit process—the whole inferred when only a part is given, whole and part being alike in kind. Inversion goes one better (or worse). The new matter of its conclusion is not represented at all in its premises—not even by so much as a beggarly "part." The only semblance of its presence in the premises arises from the common element "S" in both subjects. But one subject is the negative, the contradictory, of the other, and negation is separation, opposition, not union or likeness. There is not a shred of matter in the premises common to the new matter of the conclusion, not the slenderest filament of an inferential bond. Inversion is a novel and gross form of illicit process which lugs in matter wholly new and utterly alien to the initial matter of discourse.

Bain calls immediate inferences "equivalent propositional forms," and that phrase exactly describes the obverse or converse. But the inverse, with its injected alien matter of discourse, is very far from being equivalent to the invertend. The cogency of the reasoning accordingly differs notably in passing from the old immediate inferences to the new. The truth of the obverse or of the converse is obvious and indubitable. Given, No men are immortal,

then the truth of its obverse, All men are mortal, admits no doubt. The two statements are strictly equivalent. Not so with inversion. The inverse of, All men are mortal, is, Some beings who are not men are immortal. That may be true, but its truth does not follow obviously and indubitably from the invertend. Not so easy as that is the proof of immortality. My friends all die, therefore somebody will live forever, is a wide and wild leap in the way of inference. Inversion habitually proceeds *per saltum.*

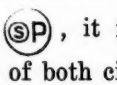
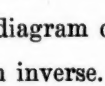
The absurdities of inversion are legion. No mathematician can square the circle; therefore some one who is not a mathematician can square the circle. No athlete can jump thirty feet; therefore some one who is not an athlete can jump thirty feet. No man can prove that two and two are five; therefore some one who is not a man can prove that two and two are five. No trouble to find absurdities. Just deny something of somebody and straightway it is true of somebody else! The trouble comes when you seek concrete examples of inversion which are not silly. Inversionists for the most part prudently stick to symbols. I am not citing these absurdities just to be witty at the expense of inversion, but because they are the superficial symptoms of deep-seated unsoundness.

Illicit process of the minor term is the salient point of my criticism. In the inverse of A there is also an apparent illicit process of the major term. Keynes and Read have attempted to explain away this weak point. I make no comment on their defense of inversion. One illicit process is quite enough, and that one to which I am now directing attention attaches not only to the inverse of A, but to every possible inverse, full or partial, derived from A, E, I, or O, for they all have $\bar{S}$ for the subject.

The advocates of inversion have two lines of proof. First in order and first in importance is the eduction series leading to the inverse by alternate obversion and conversion thus: $SaP \therefore SeP \therefore \bar{P}eS \therefore \bar{P}a\bar{S} \therefore \bar{S}i\bar{P} \therefore \bar{S}oP$. Of this series Keynes says: "If the universal validity of obversion and conversion is granted, it is impossible to detect any flaw in the argument by which the conclusion is reached" ("Formal Logic," p. 139). There is a flaw nevertheless. The series involves the assumption that the subject may be manipulated just as freely as the predicate, despite the radical difference between them. The one is *subjectum,* something placed beneath as the foundation, the essential matter of discourse; while the other is not the initial matter of discourse, but something said about it. Substituting $\bar{S}$ for S tears up the foundation and breaks the bond of inference. But substituting $\bar{P}$ for P is harmless, provided the balance is kept true by changing the quality of the proposition. For example, Some S is P $\therefore$ Some S is not not-P. The two negatives

balance each other. But $\bar{S}$, by injecting new matter of discourse, disturbs the equilibrium so profoundly that no change of quality can restore it. It is always an unbalanced negative. The deceptive semblance of balance in the double negative of the inverse (Some *not*-S is *not* P) is unreal. The two subjects, S and $\bar{S}$, being wholly different, the quality of what is said about the latter cuts no figure in restoring equilibrium. If we say Smith is honest $\therefore$ *not*-Smith (Jones for instance) is *not* honest, do the negatives balance? Not at all. The shifting ground from one subject to another is a change so stupendous as to put out of court any question of balancing negatives. It is quite a matter of indifference whether we say Jones is honest or not honest so far as concerns any inferential relation to Smith is honest. The inferential tie, because of the change of subjects, is *nil,* and nonentity is indifferent to "is" and "is not." Just so with the change from ruminants to non-ruminants. It matters not one whit whether the latter are herbivorous or not. Changing subjects is so violent a jolt to the equilibrium that one little negative more or less in the predicate is of no consequence. Whatever concrete values we assign to S and $\bar{S}$ the result is the same. They are so different that putting one for the other shatters the equilibrium so utterly that its restoration by a quality change is hopeless. The subject can not be manipulated with impunity. The basal assumption of the eduction series is fallacious. $\bar{S}$ always destroys the balance, shifts the ground of discourse, brings in alien matter, breaks the bond of inference, and produces an illicit minor term. It boots not that in the eduction series $\bar{S}$ first appears in the predicate. It comes back as the subject with all its sins on its head. By severing the bond uniting the last term to the first, it leaves the inverse, $\bar{S}$oP, dangling in empty space without any inferential support. The eduction series, the chief prop of inversion, is invalid.

As regards the "universal validity" of conversion and obversion, both are sound inferences so long, and only so long, as the integrity of the subject is preserved.

In the second place the inversionist appeals to Euler's circles. The inverse may be read off directly from them without any reference to the long and intricate eduction series. From the diagram of All S is P,  , it is obvious that Some $\bar{S}$ is not P, viz., the space outside of both circles. But unfortunately for inversion, the argument proves too much. The same inverse may be read off from  , the diagram of I or O. But I and O have no business to be sporting an inverse. By definition inversion depresses quantity, and the quantity of I, or of O, is already a minimum. Yet Euler's

method is just as liberal to them as it is to A and E. Even if we bring in the four possible diagrams of I, the inverse $\bar{S}oP$ is common to all of them. In fact every possible combination of two circles leaves outside space from which to read off $\bar{S}oP$.

It may be held that this objection is not fatal. The too prolific results of the Eulerian method may be checked by the eduction series, or by definition, thus ruling out the unwelcome results obtained from I and O. But I have shown that the eduction series is itself invalid, hence unfit to serve as a standard for testing the results of another method; and the ruling out of certain results by definition is arbitrary. Logical consistency demands either the acceptance of all inverses, those of particulars as well as of universals, or else the wholesale rejection of them all.

The inversionist may claim that the facile and indiscriminate reading off of inverses from all sorts of propositions casts doubt upon the Eulerian method rather than upon inversion. In this I am very much inclined to agree with him, though meanwhile indulging the reflection that such doubt is bad for him in the end, since it undermines his second line of defense. The legitimacy of Euler's diagrams rests upon the assumption that the relations of terms may be adequately represented by their extension alone as presented to the eye by lines and spaces on a flat field. In order to read off inverses we must further assume that outside space represents the contradictory of the term in the circle, and that this contradictory exists. Here begin modern refinements to which Euler himself was a stranger. He never dreamed of bothering the pretty head of his German princess with not-S's and not-P's.

The basal assumption is sufficiently bold. Flat spaces constitute a very inadequate presentment of the intricate relations of terms each of which is rounded up into a subtile complex of qualities as well as quantity. However, so long as we limit ourselves to the inside of the simpler diagrams, as Euler did, the method has some merit. But its modern refinements are distinctly risky. Outside space is an untamed jungle full of logical pitfalls. There it lies plain and fair to the eye, therefore the contradictories of S and P exist, and their relations may be read off at a glance! Logical relations must conform to space relations! But the study of the existential import of propositions casts doubt upon the existence of $\bar{S}$ and $\bar{P}$; and the facile reading off of inversion fallacies casts doubt upon the conformity of logical relations to space relations. Conclusions read off from the outside of Euler's circles should be held doubtful unless they have been independently confirmed. In the case of the flood of inverses (no less than six may be read off from the four diagrams of I), this independent verification is not in sight. On the contrary,

illicit process taints them all. We must discard the whole lot, or else remand them to the chapter headed "Fallacies."

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SOCIETIES

NEW YORK BRANCH OF THE AMERICAN PSYCHOLOGICAL ASSOCIATION

THE New York Branch of the American Psychological Association met in conjunction with the Section of Anthropology and Psychology of the New York Academy of Sciences on Monday, November 27. An afternoon session was held at the Psychological Laboratory of Columbia University, and an evening session at the American Museum of Natural History. Members dined at the Faculty Club, Columbia University. The following papers were read:

Correlations of Association Tests: R. S. WOODWORTH.

Preliminary results with the tests of controlled association prepared by Woodworth and Wells indicate rather high correlation between the tests of similar performances.

Experiments in Progress at the University of Illinois: S. S. COLVIN.

This paper reports some of the typical experiments now in progress and partly completed, but not as yet published. One of the most extensive of these is the attempt to discover the effect of learning certain motor activities on the learning of other similar activities. It differs principally from other studies on the transfer of training in the large number of subjects who participated and in the attempt to isolate the factors of accuracy and rapidity. The experiment has been conducted in two sections, the first with about 300 children of the practise school of the Charleston (Illinois) Normal School, the second with about 1,800 children in the grade schools of Bloomington, Illinois. While the results have by no means been worked out, as far as they go they show that while there is a positive transfer effect from the practise series to the test series in accuracy, the opposite is true in regard to rapidity. The test also clearly indicates the necessity of running a series of check experiments in interpreting the results.

Another study attempts to test whether it is better to learn a given task at one sitting or at several. The material used in one test was nonsense syllables. These were learned in one, two, three, and four periods, respectively. The results showed that it made absolutely no difference as to which method was employed. The test is

now being conducted with poetry as the memory material. A positive result that has so far been discovered is that there is a high positive correlation between immediate recall and recall 24 hours later. The subjects used were about 600 children in the grammar grades of the Champaign public schools.

A third test with school children, also conducted in the Champaign schools, has shown that while whispering is an aid to learning nonsense material, writing is a hindrance up to the sixth grade.

An experiment to discover the extent of children's vocabularies indicates that they are more extensive than ordinarily exposed.

Another experiment investigates the efficiency of spatial discrimination under varying degrees of brightness intensities. Among the interesting results appears the fact that there are two maxima of discriminative efficiency, a relative maximum with an illumination of about two-candle-power illumination, and an absolute maximum when employing 32-candle-power illumination. Probably the factors of attention and habituation explain respectively the two maxima. The experiment is to be continued with chromatic lights and a similar test is to be made in regard to sound.

Reaction Time to Different Retinal Areas: A. T. POFFENBERGER, JR.

In the course of an experiment in which light stimuli falling upon different regions of the retina were reacted to by either the right or the left hand, certain differences appeared. This report includes: (1) the differences in the time of reaction by the hand when the light stimulus strikes the center of vision, and points 10, 30, and 45 degrees from the fovea in a horizontal plane; (2) a comparison of the reaction times resulting from a stimulation of one eye and of both eyes. All differences were based on averages of 400 reactions and have a very low probable error. In the two subjects tested, the times increased as the distance from the fovea increased, and in all cases the reaction of the nasal side of the retina was faster than of the temporal side. Comparison with other retinal peculiarities suggests that the differences found are due to conditions in the retina rather than to differences in the speed of the central process. The reaction time upon stimulation of both eyes was faster by about .015 second than in the case of one eye, a difference due probably to the speed of transmission through the nerve centers.

Some Experiments in Incidental Memory: G. C. MYERS.

Subjects were asked to draw from memory a representation of the size of a dollar bill; to choose from a series of circles those representing the size of the respective common coins; to represent a watch-dial with Roman notation.

Of the 500 subjects (business men and students and pupils from

the university to the third grade public school), 15 overestimated the length, 88 subjects overestimated the width. In both the cases the average underestimation was very much greater than the average overestimation. All of the 117 subjects who corrected for length increased it, and all but 2 of the 124 subjects who corrected for width increased it. As a result of this finding, tests are in progress on "image measuring."

The males, as a rule, did better than the females. Of the 50 country-school teachers and 30 high-school students, however, the females did noticeably better than the males. In the watch experiment, out of 198 cases, all but 19 wrote "IV" and all but 8 wrote "VI." In the coin test the general tendency is to overestimate the large ones and to underestimate the small ones. A number of other tests now in progress were mentioned.

Visual Acuity with Lights of Different Colors and Intensities: D. E. RICE.

The comparatively recent development of illuminants of high intrinsic brightness, with the attendant variations in hue, has given a new importance to the question of visual acuity.

The proper conservation of the eyesight of those who must work almost constantly under artificial illumination makes it desirable to know what intensities and colors of illumination are best adapted to give the eye its highest efficiency.

In the study of this question two points are obviously of vital importance—namely, the exact determination of the intensities and the character of the test used to measure the acuity.

Many complicating factors enter into the problem, among them being the following: the state of adaptation of the eye; the varying sensitivity of different parts of the retina to lights of different colors in different states of adaptation; the influence of accommodation, involving the chromatic aberration of the eye; size of pupil; individual differences, including variation in sensitivity to different colors, and variations in the dioptric system of the eye.

These factors, together with the failure to determine accurately the intensities of the lights used, and the employment of different types of tests, are responsible for the wide variations which are to be found in the conclusions of different observers.

The present investigations indicate that red gives a considerably higher acuity than green, and that white may be either more or less efficient than red, depending largely upon individual differences, and upon the predominance of the long or short wave lengths.

With all lights the acuity curve rises rapidly with increase in illumination until an intensity of from one to two meter candles is

reached, after which large increases in intensity are accompanied with relatively slight increase in acuity.

Unit acuity with white light is reached at an intensity of from 25 to 35 meter candles.

The following explanation is suggested to account for the higher acuity with red illumination. Various facts seem to indicate that the cones of the retina, which are concerned in the perception of form, are more sensitive to radiations of longer wave length, while the rods are relatively more sensitive to shorter wave lengths. It appears also that there is to some extent rivalry between the brightness sense and the form sense. With red illumination, therefore, cone vision has the advantage, resulting in enhanced perception or form.

The Action of Pharmacological Agents as an Aid in the Classification of Mental Processes: H. L. HOLLINGWORTH.

Many attempts have been made to make out correlations in efficiency in various mental and motor tests with a view to their classification on the basis of function or process involved in their performance. Low correlations have usually been found between tests that seem to have many elements in common. These low correlations perhaps result from specialized skill in certain analogous performances, or in individual differences in method of performing the task assigned. The speaker presented results showing that tests can be usefully classified on the basis of the character of the influence of such a pharmacological agent as caffein. With respect to the character of the drug effect, the action time and persistence of this effect, the tests employed at once fall into groups, the members of which resemble each other. It was suggested that this resemblance pointed to similarity of process, function, or nervous mechanism involved in performance of the tasks. Individual differences in the method of performance (revealed in the introspections) are also reflected in the character and time relations of the drug effect.

Reactions to Simultaneous Stimuli: J. W. TODD.

One hundred reactions were obtained from each subject to each of the following arrangements of stimuli of medium intensities: to single light, electric shock, and sound stimuli; to the following simultaneous stimuli with instructions to react to the first-named member of the pairs and groups: light and sound; sound and light; light and electric shock; shock and light; sound and shock; shock and sound; light, shock, sound; shock, sound, light; sound, shock, light.

The following conclusions are based upon the data:

1. The reaction-time to a pair of simultaneous stimuli is shorter than the reaction-time to either member of the pair presented alone.

2. The reaction-time to three simultaneous stimuli is shorter than that to a pair of stimuli.

3. The addition of another stimulus to one or to two stimuli reduces the reaction-time, and reduces it in accordance with the reaction-time to the stimulus added, *i. e.*, the addition of sound, which produces the shortest reaction-time, brings about the greatest reduction; the addition of the electric shock causes less reduction, while the addition of light, which produces the longest reaction-time, produces the least reduction.

On the Relation of Quickness of Learning to Retentiveness: DARWIN OLIVER LYON.

Close inspection shows the problem to be a very elaborate one. Not only must we settle it for various *classes* and *ages*, but we must use various *methods* of learning and, most important of all, various *kinds* and *lengths* of material. When it comes to the problem of ascertaining the subject's degree of retentiveness, various methods present themselves. Of these the two used chiefly in this work have been: (1) to have the subject write down, after a certain number of days, as much of the material as possible, and measure his retentiveness by the work produced; (2) to supply the subject with the original material and take his time for the relearning of it. Each method has its advantages and disadvantages, a discussion of which can not be undertaken in this summary. Suffice it to say that although the second method has the advantage of supplying us with an easy and accurate form of measurement, it is a question if it is a fair one to use in settling the question in hand, in that this method introduces the factor of "relearning." The method of correlation used with the second method is also open to criticism, for it may be said that it is incorrect to compare two men as having the same degree of retentiveness, one of whom takes 25 minutes to learn a passage and who one week later takes 5 minutes, and another who takes 10 minutes and three weeks later only 2 minutes, even though each may be said to have saved four-fifths of the time originally spent. A combination of both methods was used in this work by having the second method follow immediately upon the first.

The popular impression among the laity is that the slow but steady worker, even though dull, remembers his work better and longer than the more brilliant student—a corollary of which is that those who learn the quickest forget the quickest. However, in so far as reliable statistics have been gathered, it has been found that in general the most rapid learner is also the best retainer. Examination of the class records of the 132 students tested at the State Normal College at Albany also proved that the students who rank highest in their classes and who can be classed as "the most intelli-

gent'' have, as a rule, the best memories. A complete expression of the various results obtained with the various methods and materials used is obviously here impossible. Generally speaking, we may say that those who learn quickly remember longest if the material memorized is ''meaningful'' or ''logical,'' but that they forget quickly if the material is such as involves the memorizing of motor associations, as is generally the case with digits, words, and nonsense syllables. This statement, however, needs many modifications. Thus, for example, with *prose* the ratio is not nearly so marked by the second method as it is with the first. With several sets of students it was even reversed. *Words* are certainly more ''meaningful'' than nonsense syllables; yet by the second method the ratio is found to be more pronounced for words than for nonsense syllables or digits, *i. e.,* the percentage of time lost by the fast learners is greater than that lost by the slow learners; and though this is true for digits also, it seems to be more true for words. For nonsense syllables (which one would think were material *par excellence* for the memorizing of motor associations) the ratio is not nearly as high as it is for digits and words. Although averaging the two methods gives a positive correlation for both *prose* and *poetry,* the second method taken alone does not always do so. This is especially so in the case of *poetry,* where the second method almost invariably gives the result that the fast learners have forgotten more than the slow ones. We are led to suspect that the explanation lies in the fact that in the memorizing of poetry *rhythm* is a most important factor. Taking all methods and materials into consideration, we can state quite positively that the amount of difference in retentiveness between the fast learner and the slow learner is much less than is generally supposd.

The rather large mass of data obtained supply us with many rather interesting implications. (1) The retentiveness of men was found in general to be superior to that of women. (2) Individuals differ more in quickness of learning than in retentiveness. (3) The first method gives a truer index of retention than does the second, and would be more desirable were it capable of perfect measurement. (4) Memory in the main runs parallel with intelligence and there is a positive correlation between memory and scholarship. (5) This is more marked where the material is of a ''logical'' or ''intelligible'' nature, and a good memory for digits, words, nonsense syllables, sounds, colors, etc., does not necessarily go hand in hand with great intelligence. (6) With the same individual, slow learning gives greater retentiveness than does fast learning. (7) With the same individual, retentiveness is greater if the material is memorized as a whole than if memorized in parts. (8) Among the best learners those who learn the nonsense syllables rhythmically are not the best

retainers. (9) The retention of ideas is increased by seeing that no mental work, especially work of a similar nature, is allowed to follow the memorizing. (10) Auditory and mechanical learning make recall *prompt* and *rapid,* but the *amount* recalled is generally less.

H. L. HOLLINGWORTH,
Secretary

BARNARD COLLEGE.

REVIEWS AND ABSTRACTS OF LITERATURE

The Mediæval Mind: A History of the Development of Thought and Emotion in the Middle Ages. HENRY OSBORN TAYLOR. Two volumes. London: Macmillan and Co. 1911. Pp. xv + 613; 589.

So far as the present reviewer is aware, Mr. Taylor's enterprise is in many important respects a novel one. His is not merely a new and improved version of standard presentations, but a fresh and highly ingenious attempt to supply the thoughtful reader with those various kinds of information in regard to the Middle Ages which he may be expected to crave and which he would look for in vain in the innumerable learned treatises on medieval history. The writer would make us feel "the reality of medieval argumentation, with the possible validity of medieval conclusions, and tread those channels of medieval passion which were cleared and deepened by the thought." To feel these is obviously "to reach human comradeship with medieval motives, no longer found too remote for our sympathy, or too fantastic or shallow for our understanding." That the accepted routine of medieval history does not accomplish this end is patent enough to any one who has sought to understand the Middle Ages. As Mr. Taylor says, "We must not drift too far with studies of daily life, habits and dress, wars and raiding, crimes and brutalities, or trade, and craft and agriculture. Nor will it be wise to keep too close to theology or within the lines of growth of secular and ecclesiastical institutions. Let the student be mindful of his purpose (which is my purpose in this book) to follow through the Middle Ages the development of intellectual energy and the growth of emotion. Holding this end in view, we shall not stray from our quest after those human qualities which impelled the strivings of medieval men and women, informed their imaginations, and moved them to love and tears and pity."

It might seem at first sight that if once the historian deserts those seemingly staunch foundations of political, economic, and institutional history, he will be forced to choose between a history of medieval literature or of philosophy, or run the grave danger of lapsing into scattered reflections and personal impressions detached from the solid earth of chronicled fact and event. Mr. Taylor has done none of these things. He has not written a history of literature or philosophy, nor has he at any point lost his moorings and drifted about the vague and eventless sea of haphazard generalization. Before proceeding to give a somewhat careful analysis of the volumes, which is the only way of forming a correct

notion of their character and value, one more of Mr. Taylor's *caveats* may be mentioned. He is not occupied, he says, with "the brutalities of medieval life, nor with all the lower grades of ignorance and superstition which have attracted many previous writers. He has not had these things very actively in mind when using the expression *medieval genius*. That phrase, and the like, are to be understood as signifying 'the more informed and constructive spirit of the medieval time.'"

Book I. is devoted to "The Groundwork." Here the author avails himself of the elaborate preparation for his work that he has made in writing his two admirable volumes on "Ancient Ideals" and his suggestive "Classical Heritage of the Middle Ages." As every one should know who has given any attention to the matter, the Middle Ages are far less original and peculiar in thought and institutions than was formerly supposed. The medieval culture is really the culture of the later Roman Empire—at any rate, no real understanding of the Middle Ages is possible to one unfamiliar with that culture. One can not jump from the Golden Age of Augustus to the barbarian invasions without missing just what he most needs to know in order to estimate the intellectual and emotional life of the thousand years following the disruption of the Empire. Accordingly, Mr. Taylor properly assigns some two hundred pages to the following topics: "The Genesis of the Medieval Genius," "The Latinizing of the West," "Greek Philosophy as the Antecedent of the Patristic Apprehension of Fact," "Intellectual Interests of the Latin Fathers," "Latin Transmitters of Antique and Patristic Thought," "The Barbaric Disruption of the Empire," "The Celtic Strain in Gaul and Ireland," "Teuton Qualities: Anglo-Saxon, German, Norse," and, finally, "The Bringing of Christianity and Antique Knowledge to the Northern Peoples." This portion of his work would form an independent treatise of the greatest value to those laboring under a variety of vain delusions due to the habit of the older historians of attempting to begin their histories of the Middle Ages with the so-called fall of Rome. Fustel de Coulanges, Ebert, Dill, Glover, and others have all made their contributions to the subject, but Mr. Taylor has done the work over from his own standpoint, basing his conclusions on his own independent research. He has by no means reproduced his "Classical Heritage," which supplements in certain respects the present work. In Book II. he bridges the gap between the waning culture of the sixth and seventh century and the clearly reviving culture of the twelfth and thirteenth. Toward one hundred and fifty pages fall to these early Middle Ages, to the Carolingian period and the mental aspects of the eleventh century in Italy, France, Germany, and England.

The great bulk of the work is properly taken up with the twelfth and thirteenth centuries, which, with their immediate antecedents, appear to many writers to constitute a truly remarkable and instructive period, which can be deemed from the standpoint of its constructive achievements, in art, law, education and thought, one of the chief sources of that culture which has prevailed down very nearly to the present, and which is responsible for many still current notions and social adjustments.

Indeed the so-called Renaissance and the Protestant Revolt did far less to undermine the emotional and intellectual life inherited from the thirteenth century than has commonly been assumed.

Books III. and IV. deal with the ideals first of the saints and secondly of the knights. Peter Damiani—whom Mr. Taylor has brought to life—St. Bernard, Francis of Assisi, and holy women, like Hildegard of Bingen and Elizabeth of Schönau, illustrate the beauties of ascetic devotion, while the "spotted actuality," as the author happily terms it, may be judged from the devout obscenity of Cæsar of Heisterbach, the prosaic *chronique scandaleuse* of Archbishop Rigaud's pastoral visits, and Salimbene's coarse fun. But Mr. Taylor betrays no *Schadenfreude* in the compromising details of baseness, nor does he apologize for them. They do not prove to him that the ideals of the time were mere hypocrisy, but merely that ideals in the Middle Ages excelled conduct, as is their wont. In describing "society," knightly virtue is illustrated by Godfrey of Bouillon and St. Louis, reinforced by the belated Froissart. There is a chapter on Parzival, "the brave man slowly wise," and another beautiful one on "The Heart of Heloïse," surely the loveliest woman in some centuries of whom we are fortunate enough to know anything.

Book V. shows how symbolism lay back of the art, literature, and whole thought, emotion, and speculation of the time. This subject is one of the most important for the student of the Middle Ages, whatever his special interests. Mr. Taylor illustrates current scriptural allegorizing by extracts from the highly imaginative Honorius of Autun; the "symbolic universe" finds its exponent in Hugo of St. Victor.

In Book VI. Mr. Taylor proceeds to a consideration of two important elements in the medieval heritage from the Roman Empire, its Latinity and its law. Every one who busies himself with the Middle Ages soon comes to feel that medieval Latin often has great literary charm, if one does not insist on wondering what Cicero or Horace would have thought of Abelard, St. Thomas Aquinas, or Thomas of Celano. Mr. Taylor shows a lively appreciation of both the beauty and the defects of what used to be called "low" Latin. He has chapters on the medieval attitude toward the Latin classics—for the Greek books had, with the exception of Aristotle, pretty much all gone by the board—together with many apt examples of medieval prose and verse. To any one with some knowledge of classical Latin and a fair degree of literary feeling, these chapters will prove among the most fascinating in the work. As for the chapter on the Roman and Canon laws, Mr. Taylor, who is an acknowledged authority on an important branch of contemporaneous law, is well qualified by his studies of earlier days to quench the easily satiated thirst of most of his readers for knowledge of these themes.

The second half of Volume II. is devoted to "The Ultimate Intellectual Interests of the Twelfth and Thirteenth Centuries"—to what, in short, is commonly called scholasticism. To understand in some degree the spirit and scope of scholasticism, it may be remarked, is to understand a great many tendencies of the human mind which can be readily observed at the present day, without going back to Albert or his gifted

disciple Thomas. After a consideration of the origin and general nature of scholastic speculation and its development in the twelfth century under the auspices of Abelard, Peter Lombard and others, Mr. Taylor gives an account of the rise of the Aristotle-ridden universities and the intellectual rôle of the Mendicant friars. Bonaventura, Albertus Magnus, and Thomas each has a chapter to himself, as well as the intempestive Roger Bacon and those daring spirits, Duns Scotus and Occam, who exercised so potent an influence upon later thinkers. The final chapter is admirably conceived—"The Mediæval Synthesis" which Dante offers in his "Divine Comedy." Every one likely to read Mr. Taylor's book is likely to have Dante on his shelves, and equally unlikely to possess the works of Albert or the "Opus Majus" of Bacon. If, as our author maintains, Dante's long poem is but a poetic *summa* of medieval thought and belief, the reader will find in "The Mediæval Mind" the most elaborate and satisfactory prolegomenon ever prepared for the "Divina Commedia."

Few readers who follow under Mr. Taylor's guidance the long way from Augustine to Dante will leave him without a somewhat bewildering sense of the extraordinary patience, sympathy, and intelligence which has produced the work in hand. There is ever so little that is merely formal or second-hand; the writer has read the works of others, but does not copy them out in his pages. He has doubtless been affected by their views here and there, but his own impressions and convictions are based on a first-hand acquaintance with the medieval writings themselves. He has found time and has had the industry and system necessary at once to collect his material and to assimilate it and "react" on it. To him belongs the highest tribute that the historian may win; he is at once the *érudit* and the *savant*—and of few can this be said.

JAMES HARVEY ROBINSON.

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A History of the Cavendish Laboratory, 1871–1910. London: Longmans, Green, & Co. 1910. Pp. xi + 342.

Under this modest title we have a really important chapter in the history of scientific thought. On December 22, 1909, J. J. Thomson, on whom has fallen the mantle of Maxwell, completed the twenty-fifth year of his tenure of the Cavendish professorship of experimental physics at the University of Cambridge. In deciding to commemorate the event with a *Festschrift* his colleagues and pupils eschewed the usual form which such volumes now take, viz., that of a series of technical monographs on points of special interest to the writers. Instead they adopted the plan of writing a history of the Cavendish Laboratory, over which Clerk Maxwell, Lord Rayleigh, and J. J. Thomson have in turn presided. The Cavendish Laboratory is easily the foremost British center of physical research, and of late years students from all parts of the world have come to work there. An account of the work done in this laboratory should, therefore, have a great interest for general students of science. Moreover, the plan of the volume, as shown in the letter addressed to the contributors, states:

"It is understood that the present volume should be the record not of what work was done, but of *how that work came to be done.* It is thought that the evolution of the ideas which have inspired physical teaching and research in Cambridge, and the part played in that evolution by the many eminent men who have worked in the laboratory, should be traced as far as possible; and it is hoped that the narration may be made in such a way as to be of interest even to those who are not professed students of our science."

After an introductory chapter on how the laboratory came to be built, there follows a chapter on the Clerk Maxwell period by Professor Shuster, then one on the Rayleigh period by Professor Glazebrook, and a survey of the last twenty-five years by J. J. Thomson himself. These are followed by four detailed surveys, viz: the period of 1885–1894 by Professor Newall, the period of 1895–1898 by Professor Rutherford, the period of 1899–1902 by C. T. R. Wilson, and the period of 1903–1909 by N. R. Campbell. The concluding chapter by Professor Wilberforce treats of the development of the teaching of physics. In the appendix we have some forty odd pages devoted to a list of the published memoirs based on the work done in the Cavendish Laboratory, and also a list of the workers who pursued their researches there, with their official positions, etc. The name index and the subject index which follow can not but enhance the value of the book.

As was to be expected, the various contributors did not interpret their instructions in exactly the same way. Some emphasize the personal and the social side of the work, the inspiration of the great leaders, the genial spirit of cooperation prevailing among the workers, etc. Others describe the relation of the various researches "as they appear in a general and impersonal review" (p. 226).

Professor Shuster's account of the Maxwell period is mainly personal. He describes his relations with Maxwell and the work done in the laboratory which especially interested Professor Shuster. In this, as well as in the introductory chapter, however, we get occasional flashes which illumine for us not only the personality of Maxwell, but also the general ideas which animated his labors. In the seventies it was generally supposed that the only function of a physical laboratory was to measure physical constants. Maxwell, admitting that it is characteristic of modern experiments that they consist principally of measurement, went on in his introductory lecture to add: "Our principal work, however, in the laboratory must be to acquaint ourselves with all kinds of scientific methods, to compare them, and to estimate their value. It will be a result worthy of our university . . . if, by the free and full discussion of the relative values of different scientific procedures, we succeed in forming a school of scientific criticism, and in assisting in the development of the doctrine of method" (p. 17).

It seems almost incredible that Maxwell, by many considered the successor of Newton, should have had only two or three students at his lectures, and that his laboratory equipment should have been so small that he should have found it necessary to report after a few years: "During the present term a skilled workman has been employed in the laboratory,

and has already greatly improved the efficiency of several pieces of apparatus." Genius and enthusiasm, however, seem to have been more effective than numbers and means, so that the amount as well as the quality of the work turned out was truly wonderful.

The period of Lord Rayleigh's professorship (1879–1884) was devoted especially to the determination of electrical units; and Professor Glazebrook introduces his account with a remarkably clear exposition of the character of the fundamental units of physics, leading up to the explanation of how the ratio between the electrostatic and the electromagnetic units suggests the electromagnetic theory of light.

Professor Thomson's own account is a genial review of the social side of the work as well as its relation to the demands of Cambridge University. Incidentally and parenthetically we have in a few pages (pp. 92–96) a lucid account of the considerations which led him to formulate the corpuscular or electronic theory of matter.

The detailed survey, by Professor Newall, of the work done in the laboratory between 1885 and 1894 contains a great deal of very valuable material under the subheadings: Experimental Optics, Electro-optics, Properties of Matter, Heat and Thermometry, Electricity and Magnetism, and the Passage of Electricity through Gases. The value of this and other chapters is, however, lessened for the general reader by the fact that the authors do not, or can not, owing to the limitations of space, indicate the importance or subsequent outcome of the experimental work which they describe. Thus on page 133 we are dryly told that a number of experiments by Roiti, Lecher, Wilberforce, and Rayleigh, to detect the influence of the motion of a medium on the velocity of light, failed. In view of the fact that this very question has since come to the forefront of physical discussion, and that the relativity theory is based entirely on these and similar "failures," some comment should have been vouchsafed to "those who are not professed students of our science."

The period from 1895 to 1898 was a momentous one in the history of modern physics, and the part that the Cavendish Laboratory played is told by Professor Rutherford, who was a student of J. J. Thomson's during this period, and who subsequently won the Nobel Prize for his researches on radium emanations. Professor Rutherford indicates how "amongst other discoveries it [the Cavendish Laboratory] witnessed within its walls the final proof of the nature of the cathode rays, the advent of the negative corpuscle or electron, as a definite entity, the experimental proof of the character of the conduction of electricity through gases, and the initial analysis of the radiations from radioactive matter" (p. 159).

The chapter by N. R. Campbell is perhaps more than any other in the book written with an eye for "the reader who is not a professed student of physics." It is full of suggestive ideas, and is from a philosophic point of view perhaps the most satisfactory.

The book is handsomely printed and is in every way pleasant reading. Natives of Hoboken will be sorely disappointed to find Stevens Institute credited on p. 330 to Hobsten, N. J. (wherever that may be). Most

American readers will likewise prefer *class of men* to *class of man.* A more serious misprint, liable to mislead the unwary reader, occurs in the last line on p. 93. The conductivity was due to something mixed with the *gas,* not with the *glass.*

Professional philosophers who light-heartedly speak of atoms and molecules as mere "convenient symbols" will find the reading of this book, or of some of the memoirs mentioned in it, very troublesome. For not only are these "mere concepts" conceived as objective physical entities, but people in Cavendish Laboratory persist in counting them, weighing them, measuring their dimensions, and determining the electrical charges on the minute corpuscles which compose these bodies. No doubt the experimental work is largely interlarded with a great deal of conscious or unconscious assumption; and it can not be said that very clear lines are here always drawn between experimental results and the theories which are intended to explain them. Nevertheless, until some other explanation of this vast mass of experimental work is forthcoming, the theories of Joseph J. Thomson and his disciples will—at least in the eyes of those familiar with the facts—hold the field.

MORRIS R. COHEN.

COLLEGE OF THE CITY OF NEW YORK.

JOURNALS AND NEW BOOKS

THE PHILOSOPHICAL REVIEW. July, 1911. *The Ontological Problem of Psychology* (pp. 363–385): GEORGE TRUMBULL LADD. – Three topics are considered: first, the more or less scornful objections to the whole subject of ontology; second, the relation of ontology to real human interests; third, the progress attained toward answering the ontological problem of psychology. The greater part of the article is devoted to a discussion of the first topic. The present condition and future prospect of the ontological problem of psychology is considered and illustrated from the corresponding problem in the physical sciences. The concepts space, time, force, and substance are analyzed. *Knowing Things* (pp. 386–404): JOHN E. BOODIN. – "In dealing with things *as known,* we place ourselves at once at the pragmatic point of view—things as they must be *taken* in our systematic experience." "Qualities must be taken as objective, if they enable us to identify and predict the things with which we must deal." Qualities are further distinguished from sensations, relations, and values. *Professor Pringle-Pattison's Epistemological Realism* (pp. 405–421): ALFRED H. JONES. – "The salient feature of this theory . . . consists in a substitution of what the author calls epistemological realism or dualism for the metaphysical dualism of English and continental philosophy. This new form of dualism differs from the traditional form of the theory in that it makes the independent or realistic existence of objects a fact of knowledge or conscious experience instead, as is usually done, of reality or existence." *Reviews of Books* (pp. 422–440). Bertrand Russell, *Philosophical Essays:* EVANDER BRADLEY MCGILVARY.

Pierre Mandonnet, *Siger de Brabant et l'Averroïsme latin au XIII^me^ siècle:* ISAAC HUSIK. Bruno Bauch, *Das Substanzproblem in der griechischen Philosophie bis zur Blütezeit:* W. A. HEIDEL. Dicran Aslanian, *Les principes de l'évolution sociale:* R. M. MACIVER. *Notices of New Books. Summaries of Articles. Notes.*

REVUE PHILOSOPHIQUE. August, 1911. *Les corrélations psychophysiques* (avec fig.) (pp. 115–135): DR. SIKORSKI. – Experimental results correlating sphygmograms and pneumograms with different types of mentality, normal and abnormal. *La définition du hasard de Cournot* (pp. 136–159): G. MILHAUD. – A defense of the coherency of Cournot's definitions of chance against current criticism. *La sociologie de M. Durkheim (2e. et dernier article)* (pp. 160–185): G. DAVY. – The remainder of the exposition of M. Durkheim's sociology and a brief estimate of its significance, for it really leads to philosophy and needs completion from philosophy. *Analyses et comptes rendus.* C. Dunan, *Les deux idéalismes:* A. PENJON. A. Binet, *L'année psychologique:* H. PIÉRON. A. Michotte et Prum, *Étude expérimentale sur le choix volontaire et ses antécédents immédiates:* G. L. DUPRAT. T. V. Moore, *The Process of Abstraction:* G. L. DUPRAT. Warner Brown, *The Judgment of Difference with Special Reference to the Doctrine of the Threshold:* B. BOURDON. Jacks, *The Alchemy of Thought:* G. L. DUPRAT. Martini, *I fatti psichici riviviscenti:* FR. PAULHAN. Chiappelli, *Dalla critica al nuovo idealismo:* L. DAURIAC. *Revue des périodiques étrangers.*

REVUE PHILOSOPHIQUE. September, 1911. *Vie végétative et vie intellectuelle* (pp. 225–257): F. LE DANTEC. – A reply to M. Lalande's objections to the definition of life that the author has advocated for the last fifteen years. *La catégorie de relation* (pp. 258–277): A. CHIDE. – An attempt to trace the empirical genesis of this category in opposition to dialecticians from Heraclitus down. *Le pragmatisme et l'esthétique* (pp. 278–284): J. PÉRÈS. – Pragmatism contains certain esthetic principles and the author undertakes to exhibit them, together with certain verifications in fact. *Observations et documents. Le rêve et la pensée conceptuelle:* DUPRAT. Whitehead and Russell, *Principia Mathematica:* H. DUFUMIER. L. Couturat, O. Jespersen, R. Lorenz, W. Ostwald, L. Pfaundler, *Weltsprache und Wissenschaft:* A. L. Déjerine et Gauckler, *Les manifestations fonctionelles des psychonévroses:* DR. CH. BLONDEL. J. Dubois, *Le problème pédagogique:* L. DUGAS. P. Mandonnet, *Siger de Brabant:* F. PICAVET. Noel, *Œuvres complètes de J. Tauler:* F. PICAVET. Baeumker, *Witelo, philosophe et naturaliste du XIIIe siècle:* F. PICAVET. L. Adelphe, *De la notion de souveraineté dans la politique de Spinoza:* G. RICHARD. C. Richter, *Nietzsche et les théories biologiques contemporaines:* L. ARRÉAT. R. M. Wenley, *Kant and his Philosophical Revolution:* J. SEGOND. Tari, *Saggi di estetica:* C. LALO. *Revue des périodiques étrangers.*

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NOTES AND NEWS

ONE of the great founders of the science of physical anthropology has passed away in the person of Dr. Paul Topinard. He was a pupil, colleague, and friend of the illustrious Broca, a "man who," Dr. Beddoe said, "positively radiated science and the love of science; no one could associate with him without catching a portion of the sacred flame. Topinard has been the Elisha of this Elijah." Topinard made valuable investigations on the living population of France, and many researches in various other branches of physical anthropology. In 1876 he published a relatively small book, "L'Anthropologie," for which he obtained a gold medal from the Faculté de Médecine de Paris, and a second prize from l'Institut; it was translated into English, and published in the Library of Contemporary Science in 1878. This book is packed with information, as it contains numerous measurements and an exposition of methods of investigation; it has long been a guide for students and a manual of reference for travelers and others. In 1885 he published his "Éléments d'Anthropologie générale," a monumental work of 1157 pages, being the substance of his courses of lectures and laboratory instruction for eight years in the École d'Anthropologie. It is not the compilation of a mere library student, but is permeated by the author's personality and contains the results of his very numerous and varied researches; in it he broke free from the traditions of the monogenists and polygenists, and incorporated the new ideas spread by Darwin and Haeckel. This great work exhibits his vast erudition and untiring energy, and it is indispensable for all physical anthropologists. It is needless to add that Dr. Topinard has gained honors in his own country and the homage of his colleagues all over the world.—*Nature.*

MR. N. C. NELSON, instructor in anthropology in the University of California, has been appointed assistant curator in the department of anthropology in the American Museum of Natural History. He will assume his duties next June and give special attention to North American archeology.

DR. W. R. BOYCE GIBSON, lecturer in philosophy at the University of Liverpool, has been appointed professor of mental and moral philosophy at the University of Melbourne.

A GUIDE to "The Philosophy of Bergson," by A. D. Lindsay, a young Scotchman, will be brought out by Doran.